Astronomy Group(Annual Report)

journal or publication title	The science reports of the Tohoku University. Ser. 8, Physics and astronomy
volume	9
number	1
page range	105-112
year	1988-07-25
URL	http://hdl.handle.net/10097/25671

Astronomy Group

Academic Staff

Professors	Keiya Takakubo and Kazuo Suda
Associate Professors	Mine Takeuti and Makoto Tosa
Research Associates	Kei-ichi Uji-iye, Shin'ichi Tamura and Osamu Kaburaki
Secretaries	Midori Nakamura and Kimiko Shibuya
Research Students	Masataka Fukunaga, Yasuki Kumai and Naomi Hirano
Graduate Students	Minoru Umezu(D6), Katsunori Shibata(D6), Kin-ichi Isobe(D4), Motoyoshi Itoh(D3), Toshiya Kimura(D3), Tomofumi Nakakita(D3), Masafumi Matsumura(D3), Toshio Uchida(D2), Norio Saitoh(D2), Hiroshi Takemiya(D2), Akiko Fukunaga(D2), Toshihito Ishida(D1), Sachiko Uemura(D1), Tomofumi Umemoto(D1) and Yuichi Hashi(D1) Masashi Chiba(M2), Masatoshi Nakayama(M2), Hiroaki Hanaoka(M2), Masaya Saitou(M1) and Tadashi Taniguchi (M1)
Guests	Munezo Seki(Colledge of General Education, Tohoku University), Toshiki Aikawa and Yutaka Sabano

Research Activities

(I) STAR

a. Stellar Structure and Evolution

M. NAKAMURA(Present address: Fukuoka-district Meteorological Observatory) and Y. NAKAMURA(Present address: Fuculty of Education, Fukushima University) published the second and third one of a series of papers on the case A evolution of massive close binary systems. In the second paper[1], the evolutionary characteristics of the systems belonging to two evolution types, which were designated as 1C2COf and 1Nc2COf in the first paper, have been presented. These two types are most complicated in the evolutionary behaviour, which consists of repeated detached, semi-detached, and contact phases. Evolutionary behaviour of the systems are also discussed, compared with the thermal relaxation oscillation model. In the third paper[2], the evolution of three close binary systems of total mass of 20.4 $M_\odot$ in and after the phase of mode Br mass-transfer in case A of mass exchange has been investigated. In every case of these systems, a secondary component evolves to interfere with the progress of primary's evolution and the system overflows the outer critical

surface before the primary completes its nuclear-burning evolution. A summary of evolution of the systems studied in their series of papers up to the stage of L_2-overflow has been given together with discussions from the observational aspects.

b. Pulsating Stars

TAKEUTI[3] argued that a sequence of successive kinetic energy maxima at expanding phases of a pulsating star can be studied as a first return map in nonlinear dynamics. It was suggested that transition from strictly periodic stellar pulsation to irregular one can be explained by the change in the rate of dissipation.

AIKAWA[4] investigated the first return maps of a sequence of hydrodynamic stellar models showing transition from periodic pulsations to irregular ones. The luminosity $\log(L/L_\odot) = 3.505$, and the effective temperature $Te = 5300$ K with the range of the mass $1.4\ M_\odot \leqq M \leqq 1.5\ M_\odot$ were chosen for the models. With decreasing the mass, the transition appeared. It was confirmed that the transition is induced by disappearance of two fixed points, as the mass is the control parameter, and that the intermittency is that proposed by Pomeau and Manneville.

TAKEUTI[5] considered the physical cause of intermittent outbursts found in the pulsations of radiative hydrodynamic stellar models found as above. The effect of radiation pressure, which will not yield the outburst in convective models, was suggested as a candidate process for the phenomena.

AIKAWA[6] investigated linear nonadiabatic pulsations of less-massive supergiant stars near the blue edge of instability strip for the fundamental mode. It was found that a driving force due to the negative gradient of density perturbations becomes important with increasing luminosities. He concluded that it makes the blue edge luminous models to be pulsationally unstable, together with the effect of radiation pressure.

SAITOU[7] applied the phase-difference minimization (PDM) method to investigate the period changes of a cepheid variable, ξ Geminorum. The observational data from 1897 to 1979 are used. The period change of $[\Delta P/P]_{100} = -4.51(\pm 3.55) \times 10^{-4}$ is obtained. The result is agreement with that of the O-C method. The validity of the PDM method for period changes is discussed.

UJI-IYE, AIKAWA, ISHIDA, and TAKEUTI[8] investigated hydrodynamic cepheid models to search the dependency of modal coupling on their physical properties together with the coefficient of artificial viscosity. It was found that the increase of artificial viscosity works like the decrease of surface-gravity. No long-living double-mode pulsations were found.

ISHIDA and TAKEUTI[9] constructed a helium-enriched model cepheid to compare the amplitude-amplitude relationship of radial modes. The helium-enriched model shows still single-period characteristics similar to the normal model.

c. Accretion Discs

KABURAKI[10] refined his previous study on the structure of thin but finite accretion discs in external magnetic fields. The vertical flow and current as well as the radial pressure gradient in the disc are newly included in the calculation. The electrodynamical processes taking place in such a disc were clarified by using an approximate steady-state solution obtained analytically. It was shown that the electrodynamical process alone is sufficient to construct a self-regulating accretion disc, without recourse to the presence of sufficiently large viscosity which is now controversial. In this model, the effective resistivity of a plasma takes the place of viscosity.

Publications

1) Case A Evolution of Massive Close Binary Systems. II. Evolution of the Systems Belonging to the Evolution Type 1C(Nc)2COf, M. Nakamura and Y. Nakamura, Astrophys. Space Sci. 134 (1987) 161 = Sendai Astronomiaj Raportoj N-ro 314.
2) Case A Evolution of Massive Close Binary Systems. III. Evolution in and after the Phase of Mode Br Mass-Transfer, M. Nakamura and Y. Nakamura, Astrophys. Space Sci. 134 (1987) 219 = Sendai Astronomiaj Raportoj N-ro 315.
3) A Discrete-Dynamic Study of Pulsating Stars, M. Takeuti, Astrophys. Space Sci. 136 (1987) 129 = Sendai Astronomiaj Raportoj N-ro 317.
4) The Pomeau-Manneville Intermittent Transition to Chaos in Hydrodynamic Pulsation Models, T. Aikawa, Astrophys. Space Sci. 139 (1987) 281 = Sendai Astronomiaj Raportoj N-ro 321.
5) The Cause of Intermittent Outbursts in Radiative Hydrodynamic Stellar Models, M. Takeuti, Astrophys. Space Sci. 140 (1988) 431 = Sendai Astronomiaj Raportoj N-ro 325.
6) Pulsation Deriving Forces in Less-massive Supergiants, T. Aikawa, Science Reports Tohoku Univ. 8th Ser. 8 (1988) 113 = Sendai Astronomiaj Raportoj N-ro 329.
7) Period Changes in a Classical Cepheid ξ Geminorum Determined by the Phase-Dispersion Minimum, M. Saitou, Science Reports Tohoku Univ. 8th Ser. 8 (1988) 107 = Sendai Astronomiaj Raportoj N-ro 328.
8) A Study of Time-Evolving Hydrodynamic Cepheid Models, K. Uji-iye, T. Aikawa, T. Ishida, and M. Takeuti, in Stellar Pulsation, eds. A.N. Cox, W.M. Sparks and S.G. Starrfield (Springer Verlag), p.204 (= Lecture Notes in Physics 274).
9) Effect of Helium Enrichment in a Classical Cepheid Model, T. Ishida and M. Takeuti, Science Reports Tohoku Univ. 8th Ser. 8 (1988) 129 = Sendai Astronomiaj Raportoj N-ro 330.
10) Mass Accretion Processes in Magnetic Fields: Formation of Quasi-Keplerian Discs, O. Kaburaki, Mon. Not. R. Astr. Soc. 229 (1987) 165 = Sendai Astronomiaj Raportoj N-ro 323.

(II) GALAXIES AND INTERSTELLAR MATTER

KIMURA and TOSA[1] studied dynamical evolution of a gas cloud strongly compressed by an external pressure as a model of molecular gas clump in HII regions. A shock wave is formed from the surface of the cloud and propagates towards the cloud center. The shock sweeps the gas and forms a spherical thin shell of the compressed gas converging towards the center. The shell breaks into small fragments as a result of the gravitational instability before the gas cloud collapses as a whole. This is a possible mechanism of formation of the stellar association around HII regions.

TOSA[2] considered the effect of formation of the molecular gas clouds in the galactic shock waves on the hydrostatic equilibrium of the galactic gas disk. The formation of gas clouds reduces the density of the diffuse intercloud gas, and the newly formed cloud expels the magnetic field through the turbulent diffusion. The reduction of the density of the diffuse gas and the increase of the magnetic pressure expand the diffuse gas in vertical direction. He found that the thickness of the diffuse gas is significantly increased in spiral arms where molecular clouds are efficiently formed. This explains the galactic spurs observed in nonthermal radio emission in the tangential direction of the spiral arms.

MATSUMURA and SEKI investigated the light scattering properties of interstellar dust grains and applied their results for an external galaxy, M104, to interpretate optical polarization data for this galaxy. (The article will be published in Astronomy and Astrophysics.)

Publications

1) Formation of Stars by Implosion of a Gas Cloud, T. Kimura and M. Tosa, Astrophys. Space Sci. 129 (1987) 261 = Sendai Astronomiaj Raportoj N-ro 318.
2) Vertical Expansion of the Galactic Gas Disk bihind the Spiral Shock Waves, M. Tosa, in "Interstellar Magnetic Fields", ed. R. Beck and R. Gröve (Springer Verlag), p.123.

(III) OBSERVATIONS

a. Molecular Emission Lines

Radio measurements of molecular emission lines using 45-m telescope of the Nobeyama Radio Observatory (NRO, Tokyo Observatory) were made by the radio astronomical group: TAKAKUBO, SEKI, KAMEYA(NRO), HIRANO, UMEMOTO, NAKAYAMA, and HANAOKA.

(1) NGC 7538 molecular cloud

The interface between the HII region and molecular cloud of NGC 7538 was studied in the CO(1-0) line data. The map of peak antenna temperature shows a shell structure surrounding the HII region. The shell is most likely a shocked region produced by the expansion of the HII region. A cluster of

infrared sources (IRS 1-3) is located in this region, but other IR objects, IRS 9 and IRS 11, are not associated with the shell and are apparently not formed by the shock from the HII region[1].

The J = 1-0 line measurements of CO, ^{13}CO, HCO^+, and HCN show a structure surrounding IRS 9 elongated in east-west direction (0.5 pc × 1.4 pc). It is intimately related to the bipolar flow at IRS 9 and may be a rotating disk, since the pattern in the velocity maps systematically changes with the radial velocity. Near IRS 1 also there is a similar structure.

(2) The bipolar flow in B335

The high-velocity CO(1-0) emission shows a distinct bipolar pattern centered at IRAS 19349+0727. The bipolar lobes delineate remarkable collimation toward the IRAS source, indicating that the flow is forcused within 0.02 pc of the driving source. There is no evidence of another evolved bipolar flow as previously suggested. B335 is a site of very recent star formation, containing a single bipolar flow with an age of 3×10^4 years[2].

The integrated intensity of ^{13}CO emission tends to be weak along the axis of the flow, especially, at the tail end of the blue-shifted lobe no ^{13}CO emission exists, indicating that the flow made a cave on the surface of the cloud. On the periphery of the flow lobes the integrated intensity shows ridges which are probably made of gas swept out by the high-velocity flow.

(3) B361 core

J = 1-0 emission of CO and ^{13}CO molecules suggests that the central region of B361 is clumpy. The mass of each clump is of the order of one solar mass. One of those which situated near IRAS 21106+4712 shows a local line broadening probably due to the effect of the IRAS source.

(4) A region between S255 and S257

A dense cloud between two visible HII regions, S255 and S257, was mapped using the lines of CS(1-0, 2-1) and $C^{34}S$(1-0). This was apparently made by the compression due to the expansion of the two HII regions. The velocity gradient suggests the rotation of the cloud. The virial mass is some hundreds of the solar mass and the density is of the order of 10^5 or 10^6 cm^{-3}.

(5) Others

Isolated objects, B1, L810, and L1221 were observed. A blue-shifted high-velocity flow was detected in B1 and the flow is seemingly very young (time scale ∿5000 years). In L810 a bipolar flow centered at an IRS was found.

An ERIDANUS' TSS terminal (FMR-60FD) to access to the NRO host computer was introduced.

b. OH Emission Line

On the occasion of IAU Symp. No.131 "Planetary Nebulae", Mexico city, Mexico, 1987, TAMURA presented the preliminary result on the first detection

of OH emission line at 1667 MHz from the planetary nebula, IC 4997 in collaboration with I. Kazès(Observatoire de Paris) based upon the observation at Nançay Radio Observatory, France. Although it is not yet confirmed at other observatories, a weak, but clear sharp emission line was distinguished at the radial velocity of -11 km/sec which is different from both HI(-64 km/sec) and optical(-44.0 km/sec) observations.

c. Optical Observations

(1) Stars

SEKI[3] in collaboration with A. Yamasaki(Tokyo University), carried out photoelectric photometry of a binary star EL Eri at Mauna Kea Observatory and discussed physical quantities and the evolutionary state of an almost-contact binary system. TAMURA reported highly resolved emission line profiles and their time variations of H^{+}, He^{+}, O^{++}, and Fe^{+6} in symbiotic stars, HBV 475, HM Sge, V1016 Cyg (IAU Colloq. No.103, "Symbiotic Phenomenon", Toruń, Poland, 1987). General characteristics of these observational data strongly indicated ionization stratifications among ions in various way. This work is still continuing.

(2) Planetary neburae and interstellar medium

TAMURA[4] and R.A. Shaw(Lick Observatory) published spectrophotometric results on angularly small planetary nebulae, K3-66, K3-67, and K3-71 which located in the direction of galactic anti-center. K3-67 was noticed as a He-enriched planetary nebula. It seems to be similar to M1-9 previously made its chemical diagnosis. These samples were choosed from the group of planetary nebulae which had higher radial velocities than those estimated by the galactic rotation curve and assumed distances. In order to analyze the expansion characteristics of such angularly small nebulae, TAMURA also reported emission line profiles obtained with high dispersion spectrograph with 74-inch telescope at the Okayama Astrophysical Observatory (IAU Colloq. No.108, "Atmospheric Diagnostics of Stellar Evolution: Chemical Peculiarity, Mass Loss, and Explosion", Tokyo, Japan, 1987). This year SHIBATA accomplished his Doctor thesis entitled "Studies on Planetary Nebulae based on their Emission-Line Profiles". Main motive was to find the distance-free physical parameters which could describe expansion characteristics of planetary nebulae. He found good correlations between expansion velocities and a couple of emission line intensity ratios, and discussed differences in these relations between Pop. I and Pop. II planetary nebulae. These results give clear constraints to the models of the velocity distribution and the ionization condition within the planetary nebulae. SEKI and UMEMOTO continued photometric studies of stars in and around Bok globules in order to determine the distance and the extinctions of globules.

(3) Galaxies

High-dispersion spectroscopic observations have been made of four clumps of the two clumpy irregular galaxies Markarian 297 and 325 by TAMURA[5] in collaboration with Y. Taniguchi(Tokyo Astronomical Observatory). Velocity dispersions in the Hα emission line, $32 \sim 41$ km/sec, and the virial mass of the clumps of the order of 10^8 $M_\odot$ were obtained. Two clumps of their samples show a redward wing-like excess emission which may be due to an effect of the supernova activity as a consequence of the starburst. TAMURA[6] published a result on a optical and infrared spectroscopic investigations of the starburst-nucleus galaxy, NGC 7714 in collaboration with Y. Taniguchi and K. Kawara(Tokyo Astronomical Observatory), M. Nishida(Kyoto University), and M. T. Nishida(Kobe Women's University). They found the non-circular motion of the nuclear emitting region and discussed the presence both of 10^4 supernova events and of 10^4 OB stars. They also detected H_2 and BrY emissions which lead to H_2 mass of 430 $M_\odot$ and the number of 10^4 O5 stars as ionization sources in the circumnuclear region.

Publications

1) The Interface between the NGC 7538 HII Region and its Molecular Cloud Core, O. Kameya and K. Takakubo, Publ. Astron. Soc. Japan 40 (1988), in press.
2) Bipolar Outflow in B335, N. Hirano, O. Kameya, M. Nakayama, and K. Takakubo, Astrophys. J. 327 (1988) L69 = Sendai Astronomiaj Raportoj N-ro 326.
3) BL Eri: An Almost-contact Binary System, A. Yamasaki, J. Jugaku and M. Seki, Astron. J. 95 (1988) 894.
4) Spectroscopic Analyses of the Stellar Planetary Nebulae K3-66, K3-67, and K3-71, S. Tamura and R.A. Shaw, Publ. Astron. Soc. Pacific 99 (1987) 1264 = Sendai Astronomiaj Raportoj N-ro 324.
5) High-dispersion Spectroscopy of the Clumpy Irregular Galaxies Markarian 297 and 325, Y. Taniguchi and S. Tamura, Astron. Astrophys. 181 (1987) 265 = Sendai Astronomiaj Raportoj N-ro 319.
6) Starburst Wind from the Nucleus of NGC 7714, Y. Taniguchi, K. Kuwara, M. Nishida, S. Tamura, and M.T. Nishida, Astron. J. 95 (1988) 1378.

(IV) NEW INSTRUMENTS

A color graphic display and a monochromatic hard-copy unit for NOVA mini-computer (Nippon Data General).

A technical work station (HP 9000 Model 310, Yokogawa Hewlett Packard).

Doctor Thesis

D1) The Mixing Length Theory for the Transport of Chemical Elements, Minoru Umezu.

D2) Studies on Planetary Nebulae based on their Emission-Line Profiles, Katsunori Shibata.

D3) Formation of the Gas Condensation in the Shock-Compressed Region, Toshiya Kimura.

Master Thesis

M1) Structure of Magnetic Fields in Spiral Galaxies, Masashi Chiba.

M2) The High-Density Core in Molecular Clouds and the Star Formation, Masatoshi Nakayama.

M3) Roles of the Millimeter-Wave Astronomy in the Interstellar Physics, Hiroaki Hanaoka.